FINAL REPORT

88-491 - Acute Risk Considerations for Alternate Facility and Systems Options

on

ACUTE RISK CONSIDERATIONS FOR ALTERNATE FACILITY AND SYSTEMS OPTIONS

in support of

OWMC ENVIRONMENTAL ASSESSMENT

to

ONTARIO WASTE MANAGEMENT CORPORATION

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by

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Table A.1. Facility Configuration Options A-1

1.0 INTRODUCTION

M.M. Dillon, Ltd. (MMD) is assembling the OWMC Environmental Assessment. Volume II of this effort, "Alternative Undertakings and Methods" includes evaluations of the various ways hazardous waste facilities can be configured by considering different combinations of the generic process areas. This report has been prepared by Battelle to support MMD's effort by providing insight into the relative changes in acute risk considering the proposed configurations options.

At the outset it is imperative to recognize that it is possible to provide only relative comparisons of risk because, at this time, the quantitative acute risk analysis program that Battelle is conducting for OWMC has not been completed. Hence, even the relative risk judgments made herein must be considered preliminary.

Acute risk is defined as the frequency of various consequences, measured by their impact on worker and public health, that could occur due to accidents at the facilities. These accidents, due to equipment failure and human error, consider hazards such as fires, explosions, and toxic vapor release. As defined, acute risk is complementary to (i.e. in addition to) chronic risk that results from the anticipated "normal" emissions from the facilities (per ENVIRON Memo dated 9/3/87 to Dillon).

The acute risk types that are addressed in this report are:

- Acute public risk, individual and population
- Acute worker risk, individual and population.

Because acute risk is a combination of the frequency and consequence of accidents, the discussions that follow will address how each facility configuration is expected to reduce or increase these two components of risk for each risk type.

A list of facility configuration options with site-by-site descriptions is provided in Appendix A, Table A.1. Discussions of these proposed configurations are provided in two sections of this report: 2.0 Partially Integrated Facility Options and 3.0 Decentralized Fully-Integrated System Options. Acute risk is addressed in each of these sections.

2.0 PARTIALLY INTEGRATED FACILITY OPTIONS

The Partially Integrated Facility Options consider different ways of separating the various generic facility units and locating different combinations of these units on one, two, or three sites. Acute risk is addressed in terms of the risk to the public due to all the units that make up a facility. The acute risk to workers is addressed in terms of on-site operations including the facility units on each site and the on-site loading/unloading of various materials as dictated by the configuration options.

2.1 Acute Risk Types and Definitions

Table 2.1 describes the 4 types of acute risk addressed in this report and their definitions as used in the evaluation of the Partially Integrated Facility Options.

2.2 Option Effects on Acute Risk Types

Table 2.2 indicates the effect each configuration option has on the various types of acute risk being considered. However, while the general direction of the effect can be estimated, the actual change in acute risk is expected to be within the range considered "low" in all cases. That is, none of the partially integrated facility options are expected to change the acute risk to an extent that the risk falls outside the range of "low" risk, which is about two orders of magnitude wide[1] and centered about the risk for a 150,000 t/a Fully-Integrated Facility Option. In general terms, "low" risk is defined to mean a level of risk which is insignificant relative to the risk being faced by any individual or population in the vicinity of the facility(ies) from all causes without the facility.

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[1] At this point, the level of acute risk for the 150,000 t/a fully-integrated facility option is being estimated in the Hazard Analysis project, conducted by Battelle. A draft report (2) was issued in October 1988 which includes an estimate of the off-site acute risk for the 150,000 t/a fully-integrated facility option.

Table 2.1. Acute Risk Types and Definitions

Risk Type	Definition
Off-Site Risks	
• Acute public risk due to accidents at facility	
- individual risk	• Measures qualitatively the frequency of Fatal Health Effects to the most exposed individual living in the vicinity of the facility due to accidents at the facility.
- population risk	• Measures qualitatively the frequency of cumulative Fatal Health Effects for the population in the vicinity of the facility due to accidents at the facility.
On-Site Risks	
• Acute worker risk due to accidents at facility	
- individual risk	• Measures qualitatively the frequency of Fatal Health Effects to the most exposed staff member due to accidents at the facility.
- population risk	• Measures qualitatively the frequency of cumulative Fatal Health Effects to the total staff present at the facility due to accidents at the facility.

Table 2.2. Option Effects for Acute Risk Types

Configuration Option	Risk Type: Off-Site Acute Public Risk Due to Accidents at Facility Individual Risk
Fully-Integrated	• low risk
P.I-1	• low, but somewhat lower than fully-integrated as incinerator and phys/chem are on separate sites and individuals are exposed to one or the other, not both.
P.I-2	• low risk
P.I-3	• low, but somewhat lower than fully-integrated as incinerator and phys/chem are on separate sites and individuals are exposed to one or the other, not both.
P.I-4	• low risk
P.I-5	• low, but somewhat lower than fully-integrated as incinerator and phys/chem are on separate sites and individuals are exposed to one or the other, not both.
P.I-6	• low, but somewhat lower than fully-integrated as incinerator and phys/chem are on separate sites and individuals are exposed to one or the other, not both.
P.I-7	• low, but somewhat lower than fully-integrated as incinerator and phys/chem are on separate sites and individuals are exposed to one or the other, not both.

Table 2.2. (Continued)

Configuration Option	Risk Type: Off-Site Acute Public Risk Due to Accidents at Facility Population Risk
Fully-integrated	• low risk
P.I-1	• low, but slightly higher than fully-integrated because each facility must have some elements which would be shared at fully-integrated site; e.g., reagents. Thus, a larger population group is exposed to the common elements.
P.I-2	• low risk, similar to fully-integrated
P.I-3	• low, but slightly higher than fully-integrated because each facility must have some elements which would be shared at fully-integrated site; e.g., reagents. Thus, a larger population group is exposed to the common elements.
P.I-4	• low risk, similar to fully-integrated
P.I-5	• low, but slightly higher than fully-integrated because each facility must have some elements which would be shared at fully-integrated site; e.g., reagents. Thus, a larger population group is exposed to the common elements.
P.I-6	• low, but slightly higher than fully-integrated because each facility must have some elements which would be shared at fully-integrated site; e.g., reagents. Thus, a larger population group is exposed to the common elements.
P.I-7	• low, but slightly higher than fully-integrated because each facility must have some elements which would be shared at fully-integrated site; e.g., reagents. Thus, a larger population group is exposed to the common elements.

Table 2.2. (Continued)

Configuration Option	Risk Type: On-Site Acute Worker Risk Due to Accidents at Facility Individual Risk
Fully-integrated	• low risk
P.I-1	• low risk, about the same as fully-integrated
P.I-2	• low risk, slightly lower than fully-integrated as landfill workers are not exposed to risk from either incinerator or phys/chem
P.I-3	• low risk, about the same as fully-integrated
P.I-4	• low risk, lower than fully-integrated as landfill and solidification workers are not exposed to risk from either incinerator or phys/chem
P.I-5	• low risk, about the same as fully-integrated
P.I-6	• low risk, lower than fully-integrated as landfill and solidification workers are not exposed to risk from either incinerator or phys/chem
P.I-7	• low risk, lower than fully-integrated as landfill workers on a separate site from both incinerator and phys/chem

Table 2.2. (Continued)

Configuration Option	Risk Type: On-Site Acute Worker Risk Due to Accidents at Facility Population Risk
Fully-integrated	• low risk
P.I-1	• low risk, but higher than fully-integrated due to increased handling of hazardous materials and non-optimal reagent storage
P.I-2	• low risk, lower than fully-integrated as landfill workers are not exposed to risk from either incinerator or phys/chem
P.I-3	• low risk, but higher than fully-integrated due to increased handling of hazardous materials and non-optimal reagent storage
P.I-4	• low risk, lower than fully-integrated as landfill and solidification workers are not exposed to risk from either incinerator or phys/chem
P.I-5	• low risk, but higher than fully-integrated due to additional handling of hazardous materials
P.I-6	• low risk, about the same as fully-integrated
P.I-7	• low risk, about the same as fully-integrated

2.3 Scaling of Risk Values by Type

In Table 2.3, acute risk types are arrayed with configuration options that affect acute risk levels. The risk posed by each option is then assigned on a relative scale. In all cases, the risk is judged to be "low." That is, it is within a range of plus or minus one order of magnitude of the risk value estimated for a 150,000 t/a fully-integrated facility which is also judged as "low".

If the 150,000 t/a fully-integrated facility were scaled up to allow expansion to 300,000 t/a, as was postulated during evaluations of other risks and impacts, the acute risk from the scaled up facility would still be judged as "low," as would the risk for each of the configuration options.

Table 2.3. Scaling of Risk Values by Type

Risk Type	Configuration Option	Scale
Off-Site Risks		
• Acute public risk due to accident conditions at facility		
- individual risk	- phys/chem and incinerator located on separate sites	Low
	- phys/chem and incinerator located on same site	Low
- population risk	- phys/chem and incinerator on same site	Low
	- phys/chem and incinerator on separate sites	Low
On-Site Risks		
• Acute worker risk due to accident conditions at facility		
- individual risk	- landfill separate from both incinerator and phys/chem	Low
	- landfill on same site as phys/chem and/or incinerator	Low
- population risk	- phys/chem and incinerator located on same site	Low
	- two-site option with incinerator and phys/chem on different sites	Low
	- three-site option with incinerator and phys/chem on different sites	Low
	- two-site option with either phys/chem or incinerator alone on a separate site	Low

3.0 DECENTRALIZED FULLY-INTEGRATED SYSTEMS OPTIONS

Section 3.0 examines a range of system options for decentralized fully-integrated facilities. Each system option considered is defined as consisting of one or more off-site treatment and disposal facilities, each of which is fully integrated. Any system consisting of a single, fully-integrated facility is referred to as a "centralized" system. Systems having more than one such facility are referred to as "decentralized" systems.

A range of annual waste volumes of 150,000 to 400,000 t/a was selected for the systems evaluation. In addition, a minimum individual facility capacity of 50,000 t/a was selected for this systems evaluation. The systems options evaluated are presented in Table 3.1. Discussion of how acute risk changes with these systems options, prior to the completion of the current hazards/acute risk study, is based on current knowledge of the acute risk and generalities of the acute risk assessment process.

Because there is a direct relationship between the implementation of any option and the resulting acute risks, individual and population, public and worker, this section will address acute risk from systems options generally rather than by specific options. At this time, the level of acute risks for the design-criterion, single, 150,000 t/a fully-integrated facility option is being estimated in the hazards analysis/acute risk study conducted by Battelle(1). Once these levels have been estimated, then by extrapolation, it will be possible to estimate the individual and population, public and worker risk levels for the various options under the three waste volume scenarios described in Table 3.1. This section describes the assumptions behind such extrapolations. It provides a relative range of risk, for each risk measure, within which risk levels for all options will fall, and it indicates, for each option, the relative change in risk that may be expected over that estimated for the criterion-designed 150,000 t/a facility. However, the estimated "central" values for each risk type, individual and population, public and worker, can come only out of the hazard analysis after "engineering fixes," etc., have been applied to the design to enhance safety and ensure low risk.

Table 3.1. Centralized and Decentralized Systems Option

Configuration Options	Total Volume of Waste (t/a)	Number of Facilities	Volume of Waste Per Facility (t/a)*
Scenario 1			
	150,000	1	150,000
	150,000	2	75,000
	150,000	3	50,000
Scenario 2			
	300,000	1	300,000
	300,000	2	150,000
	300,000	3	100,000
	300,000	4	75,000
	300,000	5	60,000
	300,000	6	50,000
Scenario 3			
	400,000	1	400,000
	400,000	2	200,000
	400,000	3	133,000
	400,000	4	100,000
	400,000	5	80,000
	400,000	6	67,000
	400,000	7	57,000

* Minimum individual facility capacity of 50,000 t/a

3.1 Assumptions

Several assumptions are inherent in estimating changes in risk levels with different systems options. These assumptions, presented in Table 3.2, are discussed below.

3.1.1 Facility Configurations

As shown in Table 3.1, for every systems option, the volume of waste to be handled by each facility is the same. For example, in a 3-facility system where the total volume of waste is 300,000 t/a, each facility would receive 100,000 t/a. It is assumed that wastes will be divided equally among facilities regardless of whether facilities are larger or smaller than 150,000 t/a. Further, it is assumed that all facilities are able to handle the same wastes.

3.1.2 Risk Level

Because OWMC intends to build and operate the final waste management option at a low level of risk, the final design will include those features required to achieve a low level of risk. It is assumed that the criterion-designed, single, fully-integrated facility with 150,000 t/a capacity is designed to fall in the center of the low risk range.[2] Regardless of the system option chosen, all potential facilities are assumed to have the same safety features as this single, criterion-designed facility. Thus, the impact on acute risk of any systems option will be relative to the single, fully-integrated facility risk level.

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[2] Battelle has prepared a Working Paper for OWMC presenting various actuarial risks and risk criteria. (1)

Table 3.2. Assumptions

1. Wastes will be divided equally among facilities regardless of whether facilities are larger or smaller than 150,000 t/a.
2. All facilities are able to handle the same wastes.
3. Final design will include those features required to achieve a low level of risk.
4. All accidents that result in fatal health effects are toxic releases.
5. Population densities at all potential sites are equal.
6. Consequences of toxic releases are proportional to the area covered by the release.
7. All facilities will be subject to the same accident scenarios.
8. The frequency of the accident scenarios changes directly with a change in the number of equipment pieces or the rate of usage of equipment.

3.1.3 Relationship of Consequence to Release Size

In general, consequences are reduced or increased as release size decreases or increases, respectively. It is assumed that all accidents that result in Fatal Health Effects are toxic releases. It is also assumed that population densities at all potential sites are equal and that the consequences of toxic releases are proportional to the area covered by the release. Finally, it is necessary to estimate the size of the area affected by a release as a function of the release magnitude.

Based on one release using a simple dispersion code, the increases and decreases in area with increased and decreased release magnitude are estimated using the following approximation:

$$A_N \approx A_O \cdot N \qquad 1/3 \leq N \leq 4,$$

where

A_N = new area
A_O = original area (150,000 t/a plant)
N = capacity of option divided by 150,000 t/a.

This estimate of affected area vs. size of release is the most tenuous assumption in this report. For example, if the capacity of a facility is reduced from 150,000 t/a to 100,000 t/a, the new affected area is 2/3 of the original area.

A similar assumption is made to estimate the new consequences:

$$x_N \approx X_O \cdot N,$$

where

x_N = new consequence
x_O = original consequence
N = capacity of option divided by 150,000 t/a.

Finally, the "threshold" effect of release size must be considered. A "threshold" release is one whose consequences entail no measurable fatal health effects. Considering all possible systems options, there must be an option for which estimated releases are so small that no Fatal Health Effects occur off-site. It is assumed here that this "threshold" effect is not important. Therefore, depending on the buffer zone size, increasing the number of facilities from one to three (capacity from 150,000 t/a to 50,000 t/a per facility), for example, could result in estimated releases so small as to produce no significant health effects outside of site the boundary. Thus, risk would be even further decreased.

3.1.4 Relationship of Accident Frequency to Facility Size

Based on the assumption (Section 3.1.1) that all facilities are identical in terms of design and safety features, it is here assumed that all facilities will be subject to the same accident scenarios. It is further assumed that the frequency of the accident scenarios changes directly with a change in the number of equipment pieces or the rate of usage of the equipment. Specifically, if the number of pieces of equipment in a particular facility area decreases, say from two to one, then the frequency of accidents related to that equipment is reduced by one half. Similarly, if the usage of a facility area decreases due to less incoming waste, say by one half, then the frequency of accident sequences related to that process are also reduced by one half.

3.2 Risk vs. Facility Size

Based on the assumptions identified in Section 3.1, the direction in which risk changes vs the number of fully-integrated facilities can be estimated. This estimate is based on increases/decreases in consequences and frequencies of accident sequences.

As plant size increases (plant capacity greater than 150,000 t/a), there will be expected an increase in some facility equipment size, an increase in some plant equipment usage, and an increase in the number of pieces of equipment for some areas. Frequencies and consequences of the

accident sequences are assumed to change linearly with these equipment changes, as discussed in Sections 3.1.3 and 3.1.4. If risk is represented as the simple product of frequency and consequence, then risk increases directly with increases in equipment and equipment usage. Thus, if facility size increases by a factor of two, it does not matter whether the change is in equipment size (consequence), equipment number (frequency), or equipment usage rate (frequency): it can be assumed that risk increases by the same ratio, a factor of two. Similarly, if facility size decreases[3], the resultant risk per facility decreases by the same ratio as the facility size decrease. Thus, for the decentralized fully-integrated systems options, on a per-facility basis, the risk can be thought of as:

$$R_N \approx N\, R_O,$$

where

R_N = new risk
R_O = original risk
N = (capacity of option)/150,000 t/a.

Because the considered capacities range from 50,000 to 400,000 t/a, the value of N ranges from 1/3 to 8/3. That is, the "low" risk for the 150,000 t/a facility will not increase by more that a factor of 8/3's and will not decrease by more than one third. Moreover, the risk will still be in the range judged as "low", that is, plus or minus one order of magnitude about the 150,000 t/a facility. Table 3.3 illustrates how this result applies to Individual and Population risk for System Options. Thus it can be concluded that both the Individual and Population risk for any of the fully-integrated dispersed options will be "low" for the public and workers.

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[3] Excluding the "threshold" effect

Table 3.3. Centralized and Decentralized Systems Option vs. Risk Range Multiplier

Configuration Options	Total Volume of Waste (t/a)	Number of Facilities	Volume of Waste Per Facility (t/a)*	Risk Multiplier (150,000 t/a baseline)	
				Individual	Population
Scenario 1					
	150,000	1	150,000	1	1
	150,000	2	75,000	1/2	1
	150,000	3	50,000	1/3	1
Scenario 2					
	300,000	1	300,000	2	2
	300,000	2	150,000	1	2
	300,000	3	100,000	2/3	2
	300,000	4	75,000	1/2	2
	300,000	5	60,000	2/5	2
	300,000	6	50,000	1/3	2
Scenario 3					
	400,000	1	400,000	8/3	8/3
	400,000	2	200,000	4/3	8/3
	400,000	3	133,000	8/9	8/3
	400,000	4	100,000	2/3	8/3
	400,000	5	80,000	8/15	8/3
	400,000	6	67,000	4/9	8/3
	400,000	7	57,000	8/21	8/3

* Minimum individual facility capacity of 50,000 t/a

4.0 REFERENCES

1. Fourth Draft Report, October 14, 1988. Hazard Analysis of OWMC Treatment Facility, Summary of Facility Risk for Typical Wastes, (Volume 1 and Volume 2), Battelle Columbus Division.

2. Draft Report/Working Paper, October 7, 1987. Hazard Analysis of Ontario Waste Management Industrial Waste Treatment and Disposal Facility, Phase III: Safety Analysis, Task 1: Development of Risk Criteria, Battelle Columbus Division.

Appendix A

Facility Configuration Options

Table A.1. Facility Configuration Options

Facility Option	Number of Sites in Option	Description by Site
Fully-Integrated Facility Option		
Centralized	1	Site A: Incineration Physical/Chemical Treatment Solidification Landfill
Partially-Integrated Facility Options		
P.I. Option 1	2	Site A: Incineration Site B: Physical/Chemical Treatment Solidification Landfill
P.I. Option 2	2	Site A: Landfill Site B: Incineration Physical/Chemical Treatment Solidification
P.I. Option 3	2	Site A: Physical/Chemical Treatment Site B: Incineration Solidification Landfill
P.I. Option 4	2	Site A: Incineration Physical/Chemical Treatment Site B: Solidification Landfill
P.I. Option 5	2	Site A: Incineration Landfill Site B: Physical/Chemical Treatment Solidification

Table A.1. (Continued)

Facility Option	Number of Sites in Option	Description by Site
P.I. Option 6	3	Site A: Incineration Site B: Physical/Chemical Treatment Site C: Solidification Landfill
P.I. Option 7	3	Site A: Incineration Site B: Landfill Site C: Physical/Chemical Treatment Solidification